

WHAT IS CLAIMED IS:

1. A thin-film magnetic head comprising a configuration in which first and second magnetic pole groups, magnetically connected to each other, having respective magnetic pole parts opposing each other on a side of a medium-opposing surface opposing a recording medium; a recording gap layer formed between the magnetic pole parts; and a thin-film coil insulated from the first and second magnetic pole groups and wound helically about at least one of the first and second magnetic pole groups or flatly spirally wound about a junction connecting the first and second magnetic pole groups to each other are laminated on a substrate;

wherein the thin-film coil comprises a first conductor group having a plurality of inner conductor parts disposed between the first and second magnetic pole groups, a second conductor group having a plurality of outer conductor parts disposed outside the second magnetic pole group or junction, and a connecting part group having respective connecting parts for connecting the inner conductor parts to the outer conductor parts;

wherein the first conductor group has an insulating contact structure in which the inner conductor parts are in contact with each other by way of an insulating film; and

wherein an inner relaxing part comprising a material softer than at least one of the first, second conductor

groups and the first, second magnetic pole groups and being in contact with the first conductor group by way of an insulating film is provided.

2. A thin-film magnetic head according to claim 1,  
5 wherein the inner relaxing part is arranged between the inner conductor part disposed on the medium-opposing surface side and the first magnetic pole group.

3. A thin-film magnetic head according to claim 2,  
10 wherein the inner relaxing part is further provided between the inner conductor part disposed on the junction side and the first magnetic pole group.

4. A thin-film magnetic head according to claim 1,  
15 wherein the second conductor group has an insulating contact structure in which the outer conductor parts are in contact with each other by way of an insulating film; and

wherein an outer relaxing part comprising a material softer than at least one of the first, second conductor groups and the first, second magnetic pole groups and being in contact with the second conductor group by way of an  
20 insulating film is provided.

5. A thin-film magnetic head according to claim 4,  
wherein the outer relaxing part is arranged between the outer conductor part disposed on the medium-opposing surface side and the medium-opposing surface.

25 6. A thin-film magnetic head according to claim 4,  
wherein, in the first and second conductor groups,

respective densities of arrangements of inner and outer conductor parts in a direction intersecting the medium-opposing surface increase from the outside of the second magnetic pole group to the second magnetic pole group.

5           7.     A thin-film magnetic head according to claim 4, wherein the inner and outer conductor parts have a variable width structure in which a path width gradually increases from a part corresponding to the second magnetic pole group to the outside thereof.

10           8.     A thin-film magnetic head according to claim 7, wherein the first magnetic pole group has a protrusion projecting toward the medium-opposing surface.

            9.     A thin-film magnetic head according to claim 8, wherein each of the inner and outer conductor parts has a  
15 narrowest part with the narrowest path width at a location corresponding to the protrusion.

            10.    A thin-film magnetic head according to claim 8, wherein the protrusion has a curved surface projecting toward the medium-opposing surface.

20           11.    A thin-film magnetic head according to claim 10, wherein each of the inner and outer conductor parts is curved in conformity to a side face form of the protrusion.

            12.    A method of manufacturing a thin-film magnetic head by laminating first and second magnetic pole groups,  
25 magnetically connected to each other, having respective magnetic pole parts opposing each other on a side of a

medium-opposing surface opposing a recording medium; a recording gap layer formed between the magnetic pole parts; and a thin-film coil insulated from the first and second magnetic pole groups and wound helically about at least one of the first and second magnetic pole groups on a substrate, the method comprising the steps of:

forming a plurality of inner conductor parts and a lower connecting layer in contact by way of an insulating film on a first magnetic pole layer disposed on the substrate and a second magnetic pole layer disposed at a location for determining a yoke length with a relaxing part gap adjoining the first inner conductor parts;

forming inner grooves covered with a separation insulating film between the second magnetic pole layer and adjacent first inner conductor parts and at the relaxing part gap;

forming each inner groove with an inner relaxing part made of a material softer than at least one of the first inner conductor part and second magnetic pole layers and a second inner conductor part, and forming a first conductor group by the first and second inner conductor parts;

forming a first magnetic pole group by laminating a third magnetic pole layer on the second magnetic pole layer;

forming a second magnetic pole group on the first magnetic pole group so as to provide the recording gap layer;

forming a connecting part group by disposing an upper connecting layer on the lower connecting layer;

forming a plurality of first outer conductor parts in contact with the second magnetic pole group by way of an insulating film, and an insulating part disposed at the position for determining the yoke length;

forming outer grooves covered with a separation insulating film between the insulating part and the first outer conductor parts adjacent each other;

forming each outer groove with a second outer conductor part, and forming a second conductor group by the first and second outer conductor parts; and

forming the thin-film coil by the first and second outer conductor groups and the connecting part group.

13. A method of manufacturing a thin-film magnetic head by laminating first and second magnetic pole groups, magnetically connected to each other, having respective magnetic pole parts opposing each other on a side of a medium-opposing surface opposing a recording medium; a recording gap layer formed between the magnetic pole parts; and a thin-film coil insulated from the first and second magnetic pole groups and wound helically about at least one of the first and second magnetic pole groups on a substrate, the method comprising the steps of:

forming a plurality of inner conductor parts and a lower connecting layer in contact by way of an insulating

film on a first magnetic pole layer disposed on the substrate and a second magnetic pole layer disposed at a location for determining a yoke length with a inner relaxing part gap adjoining the first inner conductor parts;

5           forming inner grooves covered with a separation insulating film between the second magnetic pole layer and adjacent first inner conductor parts and at the inner relaxing part gap;

10           forming each inner groove with an inner relaxing part made of a material softer than at least one of the first inner conductor part and second magnetic pole layers and a second inner conductor part, and forming a first conductor group by the first and second inner conductor parts;

15           forming a first magnetic pole group by laminating a third magnetic pole layer on the second magnetic pole layer;

          forming a second magnetic pole group on the first magnetic pole group so as to provide the recording gap layer;

20           forming a connecting part group by disposing an upper connecting layer on the lower connecting layer;

          forming a plurality of first outer conductor parts in contact with the second magnetic pole group by way of an insulating film, and an insulating part disposed at the position for determining the yoke length, while providing an  
25           outer relaxing part gap adjacent the first outer conductor parts;

forming outer grooves covered with a separation insulating film between the insulating part and the first outer conductor parts adjacent each other and at the outer relaxing part gap;

5           forming each outer groove with an outer relaxing part made of a material softer than the first outer conductor parts, and a second outer conductor part, and forming a second conductor group by the first and second outer conductor parts; and

10           forming the thin-film coil by the first and second outer conductor groups and the connecting part group.

14. A method of manufacturing a thin-film magnetic head according to claim 13, wherein each of the first and second inner conductor parts and first and second outer conductor parts is formed by plating.

15           15. A method of manufacturing a thin-film magnetic head according to claim 13, wherein the second inner conductor parts and second outer conductor parts are formed by manufacturing an electrode film by sputtering and plating  
20           a conductive layer on the electrode film.

16. A method of manufacturing a thin-film magnetic head according to claim 13, wherein the separation insulating film is formed by laminating a plurality of alumina films.

25           17. A head gimbal assembly comprising a thin-film magnetic head formed on a support, and a gimbal securing the

support;

the thin-film magnetic head comprising a configuration in which first and second magnetic pole groups, magnetically connected to each other, having respective magnetic pole parts opposing each other on a side of a medium-opposing surface opposing a recording medium; a recording gap layer formed between the magnetic pole parts; and a thin-film coil insulated from the first and second magnetic pole groups and wound helically about at least one of the first and second magnetic pole groups or flatly spirally wound about a junction connecting the first and second magnetic pole groups to each other are laminated on a substrate;

wherein the thin-film coil comprises a first conductor group having a plurality of inner conductor parts disposed between the first and second magnetic pole groups, a second conductor group having a plurality of outer conductor parts disposed outside the second magnetic pole group or junction, and a connecting part group having respective connecting parts for connecting the inner conductor parts to the outer conductor parts;

wherein the first conductor group has an insulating contact structure in which the inner conductor parts are in contact with each other by way of an insulating film; and

wherein an inner relaxing part comprising a material softer than at least one of the first, second conductor groups and the first, second magnetic pole groups and being



in contact with the first conductor group by way of an insulating film is provided.

18. A hard disk drive comprising a head gimbal assembly including a thin-film magnetic head, and a recording medium opposing the thin-film magnetic head;

the thin-film magnetic head comprising a configuration in which first and second magnetic pole groups, magnetically connected to each other, having respective magnetic pole parts opposing each other on a side of a medium-opposing surface opposing a recording medium; a recording gap layer formed between the magnetic pole parts; and a thin-film coil insulated from the first and second magnetic pole groups and wound helically about at least one of the first and second magnetic pole groups or flatly spirally wound about a junction connecting the first and second magnetic pole groups to each other are laminated on a substrate;

wherein the thin-film coil comprises a first conductor group having a plurality of inner conductor parts disposed between the first and second magnetic pole groups, a second conductor group having a plurality of outer conductor parts disposed outside the second magnetic pole group or junction, and a connecting part group having respective connecting parts for connecting the inner conductor parts to the outer conductor parts;

wherein the first conductor group has an insulating contact structure in which the inner conductor parts are in

contact with each other by way of an insulating film; and

wherein an inner relaxing part comprising a material softer than at least one of the first, second conductor groups and the first, second magnetic pole groups and being  
5 in contact with the first conductor group by way of an insulating film is provided.